

INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 2002P13270WO/CM/JJP	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. PCT/GB 03/03414	International filing date (day/month/year) 06.08.2003	Priority date (day/month/year) 21.08.2002
International Patent Classification (IPC) or both national classification and IPC H03F1/02		
Applicant ROKE MANOR RESEARCH LIMITED et al.		

- This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
- This REPORT consists of a total of 5 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of 4 sheets.

- This report contains indications relating to the following items:
 - I ☒ Basis of the opinion
 - II ☐ Priority
 - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
 - IV ☐ Lack of unity of invention
 - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
 - VI ☐ Certain documents cited
 - VII ☐ Certain defects in the international application
 - VIII ☐ Certain observations on the international application

Date of submission of the demand 01.03.2004	Date of completion of this report 09.11.2004
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Kurzbauer, W Telephone No. +49 89 2399-7479



**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. **PCT/GB 03/03414**

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, Pages

1, 4, 5 as originally filed
2, 3 received on 08.10.2004 with letter of 06.10.2004

Claims, Numbers

1-8 received on 08.10.2004 with letter of 06.10.2004

Drawings, Sheets

1/2-2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

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5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-8
	No: Claims	
Inventive step (IS)	Yes: Claims	1-8
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-8
	No: Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The subject-matter of **claim 1** concerns an RF amplifier system which varies the supply voltage according to the input signal level.

The closest prior art is given by D1: PATENT ABSTRACTS OF JAPAN vol. 0060, no. 60 (E-102), 17 April 1982 (1982-04-17) & JP 57 002107 A (PIONEER ELECTRONIC CORP), 7 January 1982 (1982-01-07) (cited on page 2 of the description) which describes an **Audio amplifier** system which varies the supply voltage according to the input signal level.

2. The problem addressed by the invention is to provide an adapted supply voltage for an **RF amplifier**.

Said problem has been solved by providing an apparatus according to claim 1 and a method according to claim 7.

3. In contrast to the disclosed subject matter in D1 an RF amplifier amplifies much higher frequencies and requires therefore different timing. Despite the principle of adapting the supply voltage is similar it can not be seen how a skilled person could modify the teaching accordingly in order to arrive at the claimed subject matter.

It can neither regarded to be obvious to modify an existing RF amplifier based on the teaching of D1 in order to arrive at the claimed subject matter.

4. Document D2: WO 02/089320 A (KO BUM-JONG) 7 November 2002 (2002-11-07) also discloses a similar structure, whereas also in D2 the amplifier is of an audio amplifier type.
5. Claim 7 differs from the teaching of D1 in that in claim 7 the supply voltage passes through a pulse shaping filter.
6. The solution provided by claim 1 and claim 7 is thus not anticipated or rendered obvious by the cited documents.

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7. Dependent **claims 2, 3, 4, 5, 6 and 8** contain further details of the system of claim 1 and the corresponding method of claim 7. As they are dependent on claim 1 and claim 7 respectively, they also satisfy the requirements for novelty and inventive step (Article 33 (2), (3) PCT).

Miscellaneous

Claim number 8 wrongly numbered as claim number 9.

above the threshold the signal is directed to the second stage amplifier. This system is somewhat limited in its application since it views the input signal as being simply low power or high power. Furthermore, it is inefficient in hardware terms because of the requirement to construct two amplifier stages, although only one will ever be used at any time. JP57 002107 describes an audio power amplifier designed to reduce switching distortion by adapting the power supply voltage to the input signal level.

In accordance with a first aspect of the present invention, an RF power amplifier system comprises a control circuit; a delay circuit and a power amplifier; wherein the control circuit comprises a detector for detecting an instantaneous power level of an input signal from a signal source; a threshold comparator; and a power supply voltage source; and a pulse shaping filter; wherein the threshold comparator is provided with a plurality of preset thresholds; wherein the threshold comparator compares the power level detected at the detector with the preset thresholds; wherein the power supply voltage is switched according to the output of the threshold comparator; and wherein the delay device delays the input signal to the power amplifier to enable the power supply voltage to be adapted to the power level detected at the detector, such that the efficiency of the power amplifier is optimised.

The present invention provides an efficient linear power amplifier in which the power supply voltage to the amplifier is changed according to the threshold reached by the detected input signal power level. Multiple thresholds are preset and associated with a suitable power supply voltage. This is a flexible system which provides a significant improvement in efficiency over conventional systems.

The system may be operated with two preset thresholds, but preferably, at least three preset thresholds are provided.

Preferably, the power supply voltage source comprises a plurality of preset power supply voltages associated with respective power level thresholds.

Preferably, at least four preset power supply voltages are provided.

Preferably, the power amplifier is a Class B amplifier and a filter is provided at the output of the amplifier to reconstitute the amplified input signal.

In accordance with a second aspect of the present invention, a code division multiple access (CDMA) communication system comprises a power amplifier system according to the first aspect.

CDMA systems use radio waves which have varying amplitudes, but the present invention is able to cope with this whilst maintaining efficiency of the amplifier by switching the power supply voltage according to the input signal power level.

In accordance with a third aspect of the present invention, a method of
5 operating a power amplifier system comprises applying an input signal from a signal source, to a control circuit and a delay device; detecting at a detector in the control circuit an instantaneous power level of an input signal; comparing the detected power level with a plurality of preset thresholds in a threshold comparator; switching a power supply voltage according to the output of the threshold comparator; and passing the
10 power supply voltage through the pulse shaping filter; wherein the delay device delays the input signal to the power amplifier to enable the power supply voltage to be adapted to the detected power level, such that the efficiency of the power amplifier is optimised.

Preferably, a plurality of power supply voltage levels, associated with respective power level thresholds, are preset.

15 An example of a power amplifier system in accordance with the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is an example of a power supply system according to the present invention;

20 Figure 2 illustrates variation in input power for an input signal using the system of Fig. 1; and

Figure 3 illustrates the corresponding variation in power supply voltage for the power amplifier of the system of Fig. 1.

Figure 1 shows one example of a power amplifier system 1 according to the
25 present invention. An amplitude variant source signal 2, containing information that is to be transmitted, is input to the system. The signal follows a first path to a power amplifier 3 via a control circuit. The control circuit comprises an envelope detector 4, which provides a value that is proportional to the instantaneous power of the input signal 2. This value is applied to a threshold detector 5 which has N, in this case 3,
30 preset thresholds, although more can be set if appropriate. An output of the threshold detector 5 controls switching of a switch unit 6 between N+1, in this case 4, discrete power supply voltages for the power amplifier. The chosen voltage then passes through a pulse shaping filter 7 to the power amplifier 3. The signal follows a second path to the power amplifier via a time delay 8, so that the power supply voltage of the

CLAIMS

1. An RF power amplifier system, the system comprising a control circuit (1); a delay circuit (8) and an RF power amplifier (3); wherein the control circuit comprises a detector (4) for detecting an instantaneous power level of an input signal from a signal source (2); a threshold comparator (5); a power supply voltage source (6); and a pulse shaping filter (7); wherein the threshold comparator is provided with a plurality of preset thresholds (TH_1 , TH_2 , TH_3); wherein the threshold comparator (5) compares the power level detected at the detector (4) with the preset thresholds; wherein the power supply voltage is switched according to the output of the threshold comparator (5); and wherein the delay device (8) delays the input signal to the power amplifier (3) to enable the power supply voltage to be adapted to the power level detected at the detector (4), such that the efficiency of the power amplifier is optimised.
2. A power amplifier system according to claim 1, wherein at least three preset thresholds (TH_1 , TH_2 , TH_3) are provided.
3. A power amplifier system according to claim 1 or claim 2, wherein the power supply voltage source (6) comprises a plurality of preset power supply voltages (V_1 , V_2 , V_3 , V_4) associated with respective power level thresholds (TH_1 , TH_2 , TH_3).
4. A power amplifier system according to claim 3, wherein at least four preset power supply voltages (V_1 , V_2 , V_3 , V_4) are provided.
5. A power amplifier system according to any preceding claim, wherein the power amplifier (3) is a Class B amplifier and wherein a filter is provided at the output of the amplifier to reconstitute the amplified input signal.
6. A CDMA communication system comprising a power amplifier system according to any preceding claim.
7. A method of operating a power amplifier system, the method comprising applying an input signal from a signal source (2) to a control circuit (1) and a delay

device (8); detecting at a detector (4) in the control circuit (1) an instantaneous power level of an input signal; comparing the detected power level with a plurality of preset thresholds (TH_1 , TH_2 , TH_3) in a threshold comparator (5); switching a power supply voltage (V_1 , V_2 , V_3 , V_4) according to the output of the threshold comparator; and
5 passing the power supply voltage through a pulse shaping filter (7); wherein the delay device (8) delays the input signal to the power amplifier (3) to enable the power supply voltage to be adapted to the detected power level, such that the efficiency of the power amplifier is optimised.

- 10 8. A method according to claim 7, wherein a plurality of power supply voltage levels (V_1 , V_2 , V_3 , V_4) associated with respective power level thresholds (TH_1 , TH_2 , TH_3) are preset.